DOCUMENT RESUME

ED 085 594 CE 000 797

AUTHOR	Foley, John P., Jr.
TITLE	Task Analysis for Job Performance Aids and Related Training.
INSTITUTION	Air Force Human Resources Lab., Wright-Patterson AFB, Ohio. Advanced Systems Div.
SPONS AGENCY	Air Force Human Resources Lab., Brooks AFB, Texas.
REPORT NO	AFHRL-TR-72-73
PUB DATE	Nov 73
NOTE	44p.; Paper presented at Conference on Uses of Task Analysis in the Bell Systems, Hopewell, New Jersey, 18 through 20 Oct. 1972
EDRS PRICE	MF-$0.65 HC-$3.29
DESCRIPTORS	*Job Training; *Maintenance; Management Development; Matrices; Slides; *Task Analysis; *Task Performance; Training; Vocational Education
IDENTIFIERS	*Troubleshooting

ABSTRACT

This paper presents several aspects of task analyses for maintenance jobs when these analyses are used as bases for the development of Job Performance Aids (JPAs) and job oriented training. It starts with a brief history of the development of task analysis technology and the part that Air Force research has played in this development. The fact that task identification is the first step in any task analysis is emphasized. After tasks are identified, the type of analysis depends on the purpose for which the analysis is being made. Task identification, based primarily on hardware analysis, is the most appropriate basis for maintenance jobs. A scheme or format to accomplish this, called a Task Identification Matrix, is presented and described. Also mentioned are a Task Description Index and Management Matrix, Task Step Data Detail Test Equipment and Tool Use Form. (The original paper was accompanied by a slide presentation and the greater part of the document consists of reproductions of these slides. The places where these slides fit into the text are indicated.) (Author/DS)

AFHRL-TR-72-73

AIR FORCE

HUMAN RESOURCES LABORATORY

ED 085594

TASK ANALYSIS FOR JOB PERFORMANCE AIDS AND RELATED TRAINING

By

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November 1973

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CE 000 797

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This final report was submitted by Advanced Systems Division, Air Force Human Resources Laboratory (AFSC), Wright-Patterson Air Force Base, Ohio 45433, under project/task number 171004. Dr. John P. Foley, Jr., Training Technology Branch, was the task scientist.

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This technical report has been reviewed and approved.

GORDON A. ECKSTRAND, Chief
Advanced Systems Division

Approved for publication.

HAROLD E. FISCHER, Colonel, USAF
Commander

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFHRL-TR-72-73	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) TASK ANALYSIS FOR JOB PERFORMANCE AIDS AND RELATED TRAINING		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) John P. Foley, Jr.		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Advanced Systems Division Air Force Human Resources Laboratory Wright-Patterson AFB, Ohio 45433		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 171004
11. CONTROLLING OFFICE NAME AND ADDRESS HQ Air Force Human Resources Laboratory Brooks Air Force Base, Texas 78235		12. REPORT DATE November 1973 13. NUMBER OF PAGES 41
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Paper presented at Conference on Uses of Task Analysis in the Bell Systems, Hopewell, New Jersey, 18-20 October 1972.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Job Oriented Training
Job Performance Aids
Task Identification Matrix
troubleshooting

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

(U) This paper presents several aspects of task analyses for maintenance jobs when these analyses are used as bases for the development of Job Performance Aids (JPAs) and job oriented training. It starts with a brief history of the development of task analysis technology and the part that Air Force research has played in this development. A formal structure is required when such task analyses have many uses. The fact that task identification is but the first step in any task analysis is emphasized. After tasks are identified, the type of analysis depends on the purpose for which the analysis is being made. Job

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Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. Abstract (Continued)

observation, questionnaire, interview, and hardware analysis are some means that are available for identification of job tasks. Task identification, based primarily on hardware analysis, is the most appropriate basis for maintenance jobs. A scheme or format to accomplish this, called a Task Identification Matrix, is presented and described. A structured scheme for analyzing the identified task for JPA development is also presented and includes documents such as the Task Description Index and Management Matrix, Task Step Data Detail Test Equipment and Tool Use Form. For maximum effectiveness and efficiency, JPAs and training should be developed to effect optimum trade off between training and JPAs. The analytic questions concerning training which must be answered by a task analysis for JPA developers and training specialist are introduced and plans for a scheme for accomplishment are mentioned.

Preface

This report represents a portion of the exploratory development program of the Advanced Systems Division of the Air Force Human Resources Laboratory. Preparation of the report was documented under Task 1710 04, Job Performance Aids for Air Force Maintenance Technicians, of Project 1710, Training for Advanced Air Force Systems. Dr. John P. Foley was the Task Scientist. Dr. Ross L. Morgan was the Project Scientist.

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1

TASK ANALYSIS FOR JOB PERFORMANCE AIDS AND RELATED TRAINING

2

First, I am grateful and honored to have this opportunity to participate in this symposium on the uses of task analysis in the Bell System. During the past several years a great deal of interest

3

has developed in the use of task analysis procedures for solving some of the critical maintenance problems both in the military and civilian sectors of the economy. One of the first visible outcomes of this type of analysis was Job Oriented Training. Over the past 15 years all of the services have supported such efforts. The so called "Systems Approach to Training" (1, 17) which is now being applied to Air Force training development is a product of Job Oriented Training research.

A more recent outcome of the task analysis approach has been aimed at technical data and has resulted in what has come to be called Job Performance Aids. Although HumRRO worked in the technical data area in their project FORECAST (14), of which Dr. Shriver was project director, the main thrust of the Job Performance Aids efforts has been by the Air Force (2). The work of the Air Force includes work by the Air Force Human Resources Laboratory, work by the Human Engineering Division of Aerospace Medical Research Laboratories and the Air Force PIMO Project (Presentation of Information for Maintenance and Operation). The most recent work of the AFHRL has included a mix of Job Oriented Training and Job Performance Aids. In the civilian sector, the Bell Telephone System, as this meeting indicates, has been one of the leaders in the use task analyses for developing more effective training and job instructions. In fact, I believe that this is the first meeting of its kind ever held.

A third area of concern, which is closely related to Job Performance Aids and Job Orientated Training is the problem of effective measures for ascertaining the ability of a maintenance man to perform the various tasks of his job. At various times in the past 20 years different agencies of the Army, Navy and Air Force have addressed this problem (3).

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4 Task analyses in some form or other have been with us for a long time. The first formal reference that I have been able to find appeared in 1911 in some of the works of Taylor on Scientific Management (15 & 16). When looked at today the ideas of Taylor look rather crude. But we now have had many years to think about the problems. The work of Taylor was carried on and extended by the time and motion studies of F. B. and L. M. Gilbreth. These works found their way into vocational education. Although we hear very little about these works today in Industrial Psychology, a link between the early work of Taylor and Gilbreth can be found in a 1932 Industrial Psychology text by Morris S. Viteles (18). Most of the early works in the area of Job and Task analysis were applied in production or manufacture. It was not until the early '50 that the techniques of task analysis began to be applied in the design of operator positions and to the study of maintenance problems.

The Industrial Psychologists and related behavioral scientists have advanced this area a great deal during the past two decades. The Air Force psychological community likes to take some credit as a prime mover in this area. We all had the pleasure of hearing

5 Dr. Bob Miller yesteday. Much of the early Air Force supported work on task analysis in the 1950's was accomplished by Bob Miller when he worked for AIR (9, 10, 11 & 12). The Air Force Technical Monitor for part of that work was my boss, Dr. Gordon Eckstrand, who is now director of the Advanced Systems Division of AFHRL. The work of our Laboratory on Job Performance Aids is a direct descendant of that work. Our work on job-oriented training has been greatly influenced by the Miller work but cannot be traced solely to that source. To carry this relationship idea a bit further, much of our laboratory's work on Job Performance Aids has been conducted under contract to Dr. John D. Folley, Jr. of Applied Science Associates, Inc. in a building at Valencia, Pennsylvania that is dedicated to Dr. Robert B. Miller, Jack Folley is now president of ASA and worked for Bob Miller at AIR in the '50s. He was coauthor of two of the above reports (11 & 12).

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6 Some of the things I am going to say may sound a little like what you just heard from Mr. Ervin. My emphasis however, will be on standardization and how to get good task analyses accomplished. It is not too difficult to get people with a behavioral science background to develop Job Oriented Training, Job Performance Aids or Job Instructions and Job Measures based on task analysis. It is quite a different matter to get traditional trainers, technical writers and testing people (who have been developing maintenance training courses, maintenance manuals and paper and pencil job knowledge tests) to completely reorient themselves to the type of job and task analysis that we are talking about. From their point of view, why should they change their ways of doing things? They feel that they are dcing a good job now. (Just as the pig iron handlers in Taylor's day, probably felt that they were doing a good job moving 12-1/2 tons of pig iron per day. Taylor indicated that a man with improved methods could move 47 tons per day (16). In Taylor's day too they just fired those individuals who would not change. We can't do this today.) To effect a change today will require education, training, and the skillful manipulation of incentives.

One of the big problems in the education and training of task analyzers and users of task analyses is a lack of agreement as to what a task analysis is and a lack of standarization in notation. A similar problem existed in mathematics 150 years ago when each mathematician used his own symbols and notation. A mathematician could not successfully communicate with other mathematicians, or effectively teach someone to be a mathematician, until a standard system of symbols and notation was established. This afternoon I am going to tell you about a first effort or start for such a standardization for task analysis. This start is published in Air Force Human Resources Laboratory's Technical Report 71-53 (5, 6, & 8).

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LEVELS OF TASK ANALYSIS

7 The process as we have used it in our work includes two levels of analysis - task identification or job analysis and analysis of the identified tasks. (I think that many people believe that task identification is task analysis - when it is only the first step.) To be effective, the analysis of identified tasks must serve the purpose for which the analysis is to be used. Some of these purposes are analyses for (1) design tradeoffs between man and machine, (2) job simplification, (3) measurement of job performance, (4) content of job instructions, (5) training for task performance, (6) determination of critical tasks and (7) preparation of job descriptions. The purpose or purposes for which the analysis is being carried out may even reflect back into how the tasks are identified. My emphasis this afternoon is on task analysis for determining the content of maintenance job instructions and the content of training, although the described task identification procedures do have broader application.

Task Identification

8 There are several ways by which tasks can be identified such as job observation, questionnaire and/or interview, hardware analysis, and critical incident techniques. Concerning the first two techniques, a good job observation program will determine what most maintenance men _do_ while they are being observed and the questionnaire and/or interview will determine what they _say they do_. Critical incident techniques also are generally based on what they say they do. For some jobs these are the only tools available for identifying tasks. But these techniques have some limitations. As we all know, what people say they do and what they actually do, may be two different things. In general, experience in gathering such information would indicate that people will say they _do_ what they think they _should do_. But what they _should do_ should be rather precisely established and communicated to them. For some jobs it is rather difficult to establish exactly what people should do. Another problem with the observation, questionnaire, interview and critical incident techniques is the difficulty of defining the limits of a task, that is, just how much of a job should be called a task.

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9 In the area of task identification for maintenance we are somewhat more fortunate. What the man should do and can do, in some cases, is limited by the hardware or equipment on which he is to perform maintenance activities. To structure the outcome of such an analysis we have devised a Task Identification Matrix.1/

Task Identification Matrix (TIM)

10 On the left hand column, we place the all system hardware components and their parts to the level for which the maintenance man has responsibility. Each line item is given a number. As headings for other columns

11 we have listed 12 maintenance actions - adjust, align, calibrate, checkout, handle, inspect, install, operate, remove, repair, service, and troubleshoot.

12 For each cell in the matrix one of the following entries is required:

O - no maintenance task of this type is performed on this end item at the level of maintenance being considered.

T - maintenance tasks of this type are performed on this end item. Indicate more than one task in a cell by a subscript that shows the number of tasks.

T_H - a task identified at this end item level is part of a task performed at some higher level in the end item list. For example, a checkout task, identified at the equipment level, may be a subroutine within a subsystem checkout or be an integral part of it.

1/ The idea of using a matrix for task identification is not new. It was used in the 1920s and 1930s by vocational educators (13). This particular application is an expansion of the matrix used in the Air Force PIMO Project (7).

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T_L — the maintenance function at this end-item level is made up of tasks performed at lower levels in the end item list. For example, a checkout at the equipment level may be made up of individual checkout tasks at the unit level.

If insufficient information is available a ? is indicated in the TIM until the information becomes available.

To properly accomplish this matrix, the maintenance concept must be considered for each line item. This device has the advantage of identifying almost every possible task in a job. It also limits the scope of each task. This Task Identification Matrix is a required sub-product of our Task Analysis Procedure.

Task Inventory

13 The next step in our task analysis process is the Task Inventory which is simply a listing and numbering of each of the task identified in the matrix. As can be seen from the slide the numbering systems starts with line item number of the TIM. Each task is also given a name which includes the name of the function and the name of hardware end item.

The Analysis of Identified Tasks

14 After each task has been identified, it is analyzed for the purpose of technical data development. This procedure is outlined starting on page 13 of AFHRL-Technical Report-71-53, Vol I. (5). As presented in the technical report this is in a columnar or matrix format. We have called this document the Task Description Index and Management Matrix (TDIMM). Each column calls for different information about the task (as indicated on the slide). The categories of information called for are not necessarily complete. I will talk more about this lack of completeness in relation to matched training. In the interest of time, I am not going to comment on each item of information. If the information for a particular cell is available in some other document, it may be more convenient to just reference the source. If the task description category is

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not relevant for the particular task, a "0" is placed in that cell. If insufficient information is available a "?" is placed in the cell, until the information is found, or is generated.

15 Returning to the task information I would like to make particular reference to the K2 column relative to task steps. The level of detail to be included in the task steps must be consistent from task to task. This consistency is obtained from the use of a standard list of verbs, and from two ground rule documents the Task-Step Data Detail Document and the Test Equipment and Tool Use Form. The Task-Step Data Detail ground rules must be applied in the development of directions for the performance of each task step.

16 The Test Equipment and Tool Use Form identifies all of the operational functions of test equipment and special tools. Some functions may be considered as part of the user's normal job repertoire and directions for their use will not be included in the job instructions. Other functions will be identified. Whenever a task requires the use of any of these test equipment functions, directions for each function will always appear in the same way.

Special Analysis for Troubleshooting Task

17 Whenever a troubleshooting task is identified in the TIM and appears in the Task Inventory, special analyses are required. These include those shown on the slide. The information gathered or generated in the first six items is used in the development of action trees (troubleshooting trees). The action tree document is used as the structure for placement of troubleshooting directions. These directions are developed with the same constraints as the task-steps for straight line tasks discussed earlier.

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Guidance Documents for Task Analysis

18 The requirements and guidance for the task analysis procedure outlined this afternoon are found in three volumes of AFHRL-TR-71-53: The first volume (5), mentioned earlier, is a draft specification for the development of Job Performance Aids for organizational maintenance. The standardized sub-products of task analysis called for by this document become firm criteria for determining the content of the maintenance instructions. In addition to the task analysis requirements, this document specifies end-product formats as to how Job Performance Aids or job instructions should look. In my opinion format is secondary. If the task analysis is properly performed, an adequate format for presenting the information will logically follow. The second volume of this technical report is a JPA Developers Handbook (6) and the third volume is a JPA Managers Handbook (8) for managers who must buy JPAs under contract. We do not claim that these documents are the final word in standardization but they are a good start.

19 In talking about support for a maintenance job it is convenient to
use a model shown on the slide. (Explain model). The documents just
described cover only organizational maintenance. We have expanded this
20 coverage in another technical report (AFHRL-TR-71-23). We plan to
expand these documents to cover the intermediate level of maintenance
21 this coming year. This expansion also will include the training consid-
eration about which I am going to talk.

TASK ANALYSIS FOR TRAINING

22 Job instructions or JPAs can be developed in keeping with the documents just described, more or less independent of training. On the other hand, training may be developed with little consideration for existing job instructions. To be most effective both should be developed with adequate consideration for the other. To be most effective training should be job-oriented. Some sort of job task identification has always been included in good vocational training. The TIM and Task Inventory

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discussed earlier offers an excellent tool for this purpose. The training specialist can analyze the tasks for training purposes independently from the technical data developer but the independent analysis of the same tasks is not very efficient. There are many common elements in the analysis of the same task for both training and job instructions. Also, the trade-offs between what should be put in training and what should be put in the job instructions should be considered together. A systems approach to training and technical data development therefore is recommended. When developing directions for the accomplishment of tasks, the JPA developer should be able to answer the following questions about each task, precisely and consistently.

23 (1) What tasks should all users know how to perform or in other words bring to the job? - Directions for these tasks can usually be omitted from the data.

(2) What task-steps or part of steps in this task should all users bring to the job? Directions for these steps or parts of steps can be omitted from the data in most cases.

(3) What steps or part of steps can a man with experience be expected to do without direction? JPA should be designed so that these steps or part of steps can be bypassed by the experienced technician.

(4) What activities are repeated so many times in the data that instructions for doing them should be assigned to training?

In answering these questions the criticality and frequency of each task must be considered. The questions cannot be answered adequately using the current guidance in the AFHRL-TR-71-53 documents. The assumption made, in these documents, is that the user may have had little or no training or practice on any of his job activities or in the use of his test equipment. The structure for establishing firm ground rules for answering the questions can be provided by modification and expansion of the Task Step Data Detail and the Test Equipment and Tool Use Documents. At least one "K" column should be added to Task Description Index and Management Matrix which will provide for modified task steps that reflect these considerations.

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The training specialist requires most of the information provided by Task Description Index and Management Matrix (TDIMM). In addition he must answer the following questions about each task.

(1) What is the normal performance repertoire of the people assigned to training with respect to this task?

(2) What skills and information are the graduate of the training program expected to bring to each task? (He will be able to obtain this information from the proposed TDIMM, Task Step Detail Document, and the Test Equipment and Tool Use Document.)

(3) What task directions, due to their special characteristics, should be included in the training as well as in the JPA's?

The list of tasks, skills and information obtained from this exercise becomes the terminal objectives of training. The training specialists and the JPA developers should jointly determine the ground rules for the Training - JPA Tradeoffs reflected in the documents referred to in connection with question (2). However, the training specialists must make their own analyses for questions (1) and (3). The answers to these questions will require added space in the current documents or will require the development of supplementary documents. With the types of task information described, the training specialist can develop the training exercises, that will bring most of the people assigned to training to the desired skill level for job entry.

As stated earlier we do not have the guidance documents that will adequately provide the optimum tradeoff between training and job instructions but we are working on it. We hope to have these provisions included in revisions to our AFHRL-TR-71-53 documents by the middle of 1973.

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SUMMARY

25 This afternoon I have talked about an effort to structure and standardize the task analysis process so that a true systems approach can be applied to the development of maintenance instructions and training for maintenance. This is possible since both the maintenance instructions and maintenance training are supporting the same job tasks. I have presented a way of identifying these tasks and of analyzing the identified tasks. The analysis is structured so that several subproducts result. These subproducts are then used as criteria which control the content of both the job instructions and supporting training. I have not emphasized the results of experiments which have demonstrated the effectiveness of this technology. However, if you are interested I have copies
26 of a recent summary of Job Performance Aids Research as well as copies of this paper which you may take with you. I, also, have some copies of the specification and handbook technical reports.

27

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List of Slides

TASK ANALYSIS FOR JOB PERFORMANCE AIDS AND RELATED TRAINING

- TASK ANALYSES OF MAINTENANCE JOBS
  - JOB ORIENTED TRAINING
  - JOB ORIENTED MAINTENANCE GUIDANCE (JOB PERFORMANCE AIDS)
  - JOB TASK PERFORMANCE TESTS

KEY NAMES

F. W. Taylor - Scientific Management

F. B. & L. M. Gilbreth - Time & Motion

M. S. Viteles - Industrial Pscyhology

EARLY A. F. WORK

Miller

A Method For Man-Machine Task Analysis
(1953)

Suggestions for Short Cuts in T. A. Procedures
(1956)

Miller & Folley

Recommendations on Designing Elec. Equip.
(1951)

The Validity of T. A. from Phototype Equip.
(1952)

IMPLEMENTATION OF TASK ANALYSIS FOR MAINTENANCE

Affects Many People

- Design Engineers
- Technical Writers
- Maintenance Men
- Industrial Psychologists
- Test Psychologists
- Training Specialist

Need Common Language and Sturcture

All can use and communicate

LEVELS OF TASK ANALYSIS

- ● ● ● Task Identification
- ● ● ● Analyses of Identified Task
- ● ● Some Purposes of Analysis
  - Design Trade-offs
  - Job Simplification
  - Measurement of Job Performance
  - Content of Job Instructions
  - Content of Training
  - Identification of Critical Tasks
  - Job Descriptions

8

SOURCES FOR TASK IDENTIFICATION

- Observation of Job
- Questionnaire and / or Interview
- Analysis Based on Hardware

TASK IDENTIFICATION 9

- Task Identification Matrix (TIM)
- Task Inventory

SLIDE 9

SAMPLE

TASK IDENTIFICATION MATRIX (TIM)

Maintenance Functions / System Hardware Levels	1 Adjust	2 Align	3 Calibrate	4 Checkout	. . . . . .	13 Troubleshoot
12. Landing gear subsystem						
. . .						
13. Communication subsystem	0	0	0	TL		0
13.1. Transmitting station	0	0	0	TL		0
13.1.1. Modulation equipment	0	0	0	TL		T
13.1.1.0.1. Power Supply	0	0	0	TH		0
13.1.1.0.2. Mod Unit	0	0	0	0		0
13.1.1.0.2.1. Speech amp	0	0	0	0		T
13.1.1.0.2.2. FSK	0	0	0	0		T
13.1.2. Transmitting set	0	0	0	T		0
13.1.2.1. Transmitter	0	T	0	0		0
13.1.2.1.1. Osc	T	0	0	0		T
13.1.2.1.1.1. SMO	T	0	0	0		0

MAINTENANCE ACTIONS CONSIDERED

1. Adjust
2. Align
3. Calibrate
4. Checkout
5. Handle
6. Inspect
7. Install
8. Operate
9. Remove
10. Repair
11. Service
12. Troubleshoot

EXAMPLE OF TASK INVENTORY

System (not including)	Subsystem	Equipment	Group	Unit	Assembly	Subassembly	Stage	Part	Maintenance Function	Task Statement
										Task Name
13	00	00	00	00	00	00	00	04	01	Checkout communication subsystem
13	00	00	00	00	00	00	00	08	01	Operate communication subsystem
13	01	00	00	00	00	00	00	04	01	Checkout transmitting station
13	01	00	00	00	00	00	00	08	01	Operate transmitting station
13	01	01	00	01	00	00	01	09	01	Remove Spark Plug #1
									02	Remove Spark Plug #2
									03	Remove Spark Plug #3
									04	Remove Spark Plug #4

TASK DESCRIPTION INDEX AND MANAGEMENT MATRIX (TDIMM)

Task Analyst ________ Page No. ____

Task Description Content Categories / Task Inventory / Task Statements & Codes	(A) Equipment Description & Operation	(B) Equipment Drawings	(C) Equipment Configuration Applicability	. . . .	M Notes

TDIMM

"K" COLUMNS

K_1	Task Initiation	K_6	Multiple Personnel
K_2	Task Steps	K_7	Maintenance Support Info.
K_3	Tolerances	K_8	Special Instructions
K_4	Notes, Cautions, Warnings	K_9	Follow on Task
K_5	Repetition (Steps)	K_{10}	Task Repetition

SLIDE 15

TEST EQUIPMENT

AND

TOOL USE FORM

SLIDE 16

SPECIAL

TROUBLESHOOTING ANALYSIS

INTERMEDIATE PRODUCTS

1. List of Components and Failure Modes.
2. List of Functions.
3. List of Function Failures.
4. Functional Unit Implication of Function Failures.
5. Malfunction Symptoms.
6. Component Block Diagrams.
7. Action Trees.
8. Draft of Checkout Procedures.
9. Reading & Tolerance Data Collection Forms.

GUIDANCE DOCUMENTS

AFHRL-TR-71-53

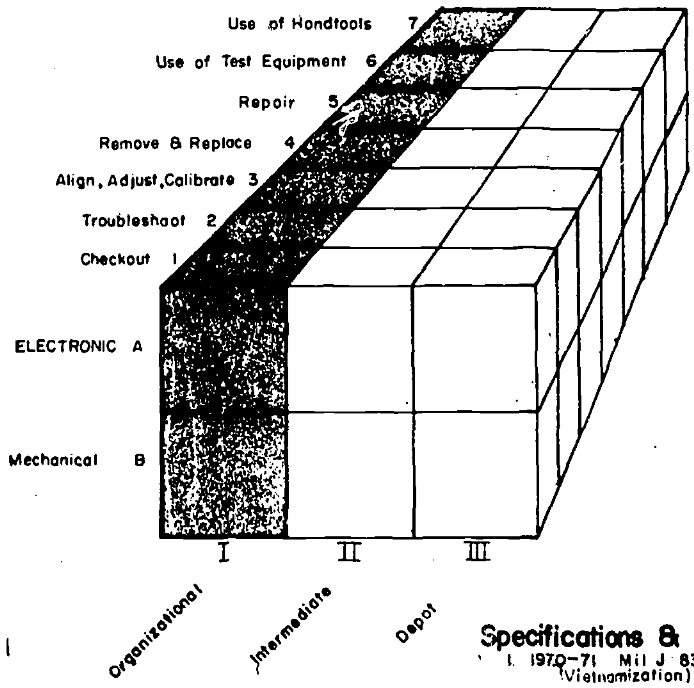
Fully Proceduralized Job Performance Aids:

Vol. I Draft Specification

Vol. II JPA Developer's Handbook

Vol. III JPA Manager's Handbook

A Functional Representation of the AF Maintenance Structure

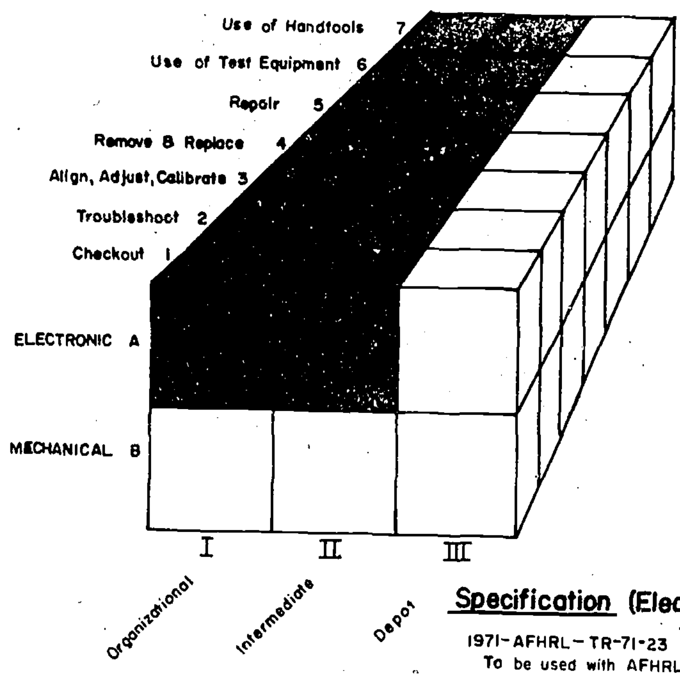


Specifications & Handbooks

1. 1970–71 Mil J 83302 (Vietnamization)
2. 1971—AFHRL TR-71-53 (American) Electronic and Mechanical Organizational Level Only

SLIDE 19

A Functional Representation of the AF Maintenance Structure

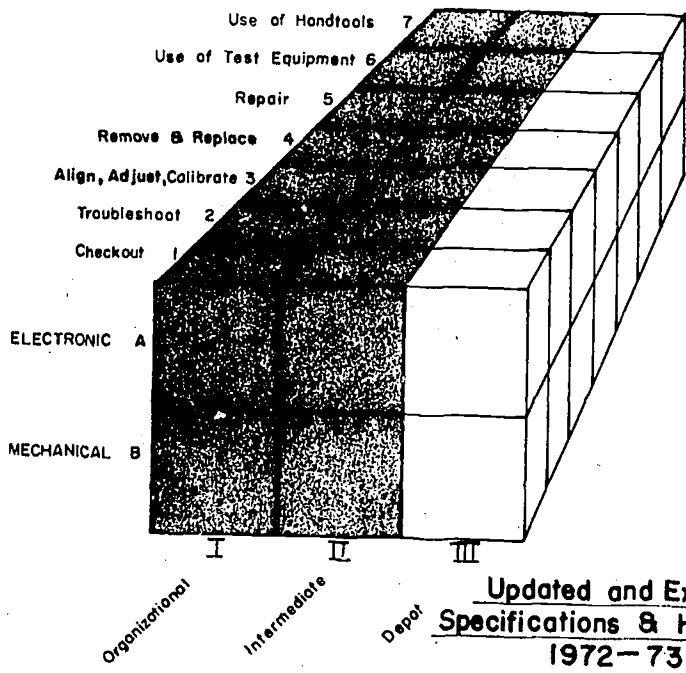


Specification (Electronic Equip)

1971-AFHRL-TR-71-23
To be used with AFHRL-TR-71-53

Organizational and Intermediate Levels
Electronic Only

A Functional Representation of the AF Maintenance Structure



Updated and Expanded Specifications & Handbooks 1972–73

Organizational and Intermediate Levels
Mechanical and Electronic

TASK ANALYSIS FOR TRAINING

DEVELOPER'S TRADE-OFF QUESTIONS

1. What Tasks - User Bring to Job?
2. What Task Steps - User Bring to Job?
3. What Steps do Experienced Man Need?
4. Repeated Activities - Assign to Training?

TRAINING TRADE-OFF QUESTIONS

1. Normal Repertoire - Trainees?

2. Skills and Information for each Task?

3. Tasks Assigned to Both?

SUMMARY

- Standardization of Task Analysis
- Task Analysis
  - Task Identification
  - Analysis of Ident. Tasks for Purpose
- System Approach - Trade-offs
- T. A. Sub-products - Criteria for Content

AVAILABLE DOCUMENTS

- JPA Research Summary
- AFHRL-TR-51-53 - Draft Spec. & Handbooks
- AFHRL-TR-51-23 - Sup for Elect - Inter.
- This Paper